Regional Analyses of Restoration Planning

PART 6 – GREAT LAKES

ESTUARIES OF THE GREAT LAKES

Situated on the mid-western border between the United States and Canada, the Great Lakes is the world's largest system of fresh surface water.

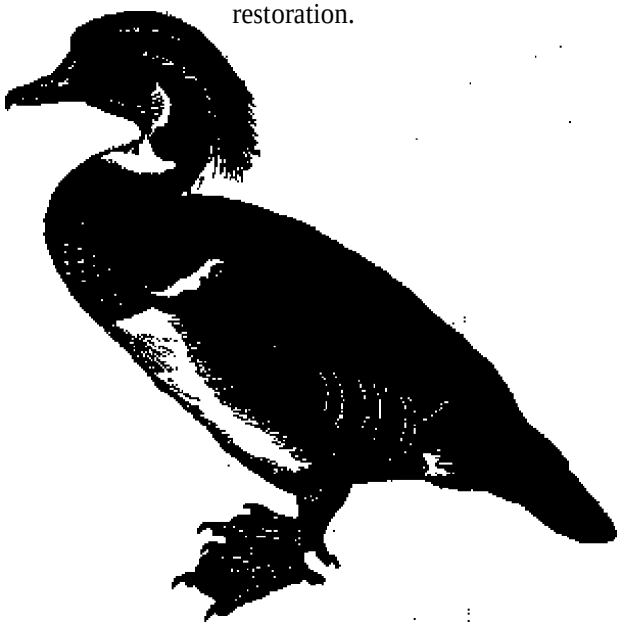
This region:

- Contains nearly 95 percent of the United States' supply and 20 percent of the global supply.
- Covers a surface area of 94,710 square miles and has over 5,500 cubic miles of water; with a combined U.S.-Canadian shoreline measuring 10,210 miles, including islands and connecting channels (excluding the St. Lawrence River).

For the purposes of this discussion, the term estuary includes near coastal waters and wetlands of the Great Lakes that are similar in form and function to estuaries (Section 103[2] Estuary Restoration Act of 2000) and is limited to the U.S. shoreline of the Great Lakes (Lakes Superior, Michigan, Huron, Erie and Ontario) and their connecting waters (St. Marys River, St. Clair River, Lake St. Clair, Detroit River, Niagara River and the St. Lawrence River to the Quebec border).

SUMMARY

The Great Lakes region contains many habitats that are considered rare in this region because of the unique formation of ecosystems (due to large freshwater lake influence). Coastal wetland restoration planning across this region as a whole is still in its beginning stages. Most coastal wetland planning efforts are conducted as part of a broader ecological effort. Many estuarine-like systems have only recently been formally identified as target areas for protection or restoration by agencies or nongovernmental organizations. One of the most significant environmental agreements in the history of the Great Lakes took place with the signing of the Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada. The agreement committed both parties to address water quality issues of the Great Lakes in a coordinated, joint fashion. Both parties agreed to develop and implement *Lakewide Management Plans* (LaMPs) for lake basins and *Remedial Action Plans for Areas of Concern.* LaMPs have been developed for all of the Great Lakes except Lake Huron and include specific objectives for coastal habitat restoration.



Introduction to the Great Lakes Region

Description

Situated on the mid-western border between the United States and Canada, the Great Lakes is the world's largest system of fresh surface water. The Great Lakes extend approximately 850 miles east to west and 700 miles north to south. Covering a surface area of 94,250 square miles and having over 5,500 cubic miles of water, the total U.S. and Canadian shoreline measures 10,210 miles, including islands and connecting channels. Of that figure, approximately half of the Great Lakes shoreline is in Canada and the remainder occurs in the states of Michigan, Wisconsin, Minnesota, Illinois, Indiana, Ohio, Pennsylvania and New York.

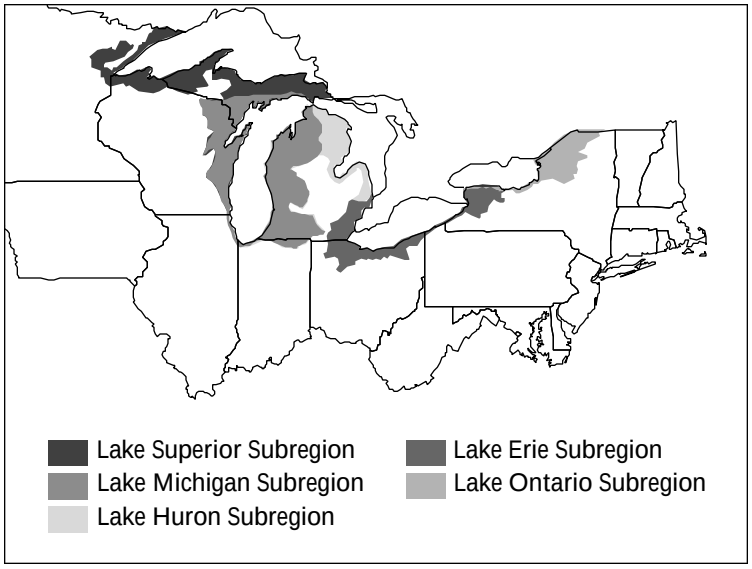


Figure 1. The Great Lakes region

Although each of the Great Lakes has its own separate characteristics, they are all part of one massive integrated water system. The lakes act as their respective drainage for their tributary waters. Lake Superior drains to Lakes Huron and Michigan (which are at the same level) through the St. Marys River. Lakes Huron and Michigan drain to the south and east though the St. Clair River into Lake St. Clair, and then through the Detroit River to Lake Erie. Lake Erie drains into Lake Ontario via the Niagara River. Together, the lakes discharge 6.5 billion gallons every hour into the St. Lawrence River at the east end of Lake Ontario (EPA, 1980).

For the purposes of this discussion, the term estuary includes near coastal waters and wetlands of the Great Lakes that are similar in form and function to estuaries (Section 103(2) Estuary Restoration Act of 2000). Great Lakes coastal wetlands differ from inland wetlands due to the influence of large lake processes, including large waves, wind-driven tides (seiches), and especially the seasonal and long-term fluctuations of Great Lakes water levels (Wilcox and Maynard, 1996).

Seiches with an amplitude of 20 to 30 centimeters and period of four to 14 hours occur regularly on the Great Lakes or within large embayments. Extreme seiches have been recorded on Lake Erie with amplitudes as great as five meters. Great Lakes levels fluctuate annually, in periods of 30 years, and periods of 150 years. Annually, high lake levels occur in early summer and low lake levels in early winter. The range between annual highs and lows since 1918 to present varied from as little as 1.19 meters on Lake Superior to as much as 2.04 meters on Lake St. Clair (USACE 1999, in Wilcox and Whillans, 1999). During the past 4,700 years, short-term fluctuations with a range of .5 to .6 meters occurred about every 30 years and longer-term fluctuations occurred with a range of .8 to .9 meters about every 150 years (Wilcox and Whillans, 1999).

Although there are substantial estuarine systems on the Canadian shore, and the ecosystem processes that are influenced by the lakes do not respect political boundaries, this discussion is limited to coastal wetlands on the U.S. shoreline of the Great Lakes (Lakes Superior, Michigan, Huron, Erie and Ontario) and their connecting waters (St. Marys River, St. Clair River, Lake St. Clair, Detroit River, Niagara River and St. Lawrence River).

In 1981, Herdendorf et al., surveyed and mapped all wetlands greater than one acre in size that occur wholly or partially within 1,000 feet of the Great Lakes shoreline. However, not all wetlands identified in this study are directly influenced by Great Lakes water levels. Wilcox and Maynard (1996) and Chow-Fraser and Albert (1999) have re-analyzed Herdendorf as part of providing information for SOLEC (State of the Lakes Ecosystem Conference) conferences. For the purposes of providing summary data for this report, these studies and additional data provided by Minnesota and Wisconsin's Coastal Zone Management Programs were combined. There are at least 883 different coastal wetland ecosystems covering at least 393 square miles on the U.S. side of the Great Lakes. It is important to note that these numbers are approximate and that they more than likely under report Great Lakes estuarine systems.

Key Habitats and Species

Great Lakes coastal wetlands include the following basic wetland types: aquatic beds dominated by floating-leaved and submergent macrophytes, emergent marshes dominated by emergent macrophytes, beach strands dominated by annual herbs, wet meadows and fens dominated by sedges, dune and swale complexes, bogs dominated by *Sphagnum sp.*, and swamps forested by a variety of lowland conifers and deciduous trees.

TABLE 1. ESTUARINE HABITATS IN NEED OF RESTORATION IN THE GREAT LAKES AND THEIR CONNECTING CHANNELS

Habitat	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
aquatic beds	❍	●	●	●	●
emergent marshes	●	▲	●	●	●
beach strands	❍	❍	❍	❍	❍
wet meadows and fens	▲	●	●	▲	▲
dune and swale complexes	▲	●	▲	▲	●
bogs	●	▲	▲	▲	▲
swamps	●	▲	▲	▲	▲

KEY: ● High Need ▲ Medium Need ❍ Low/No Need

Based on a review of the existing information and restoration plans, the natural occurrence and need for restoration, based upon the frequency with which it was mentioned in the restoration plans reviewed, varies somewhat between each Great Lake (see Table 1).

Marshes are the most common type of coastal wetland and are dominated by emergent macrophytes. This vegetation type can tolerate the short- and long-term fluctuations in water levels that occur in the Great Lakes. In fact, they actually require these fluctuations to maintain their species diversity (Wilcox and Maynard, 1996). Fen communities in the coastal Great Lakes are characterized by moderately decomposed peat, and have diverse plant communities dominated by sedges. Swamps are found along the upland margin of coastal wetlands, many of which are influenced by the Great Lakes only during periods of high water. Peatlands or bog communities usually occur towards the landward margin of coastal wetlands and in some cases form floating mats that adapt to lake-level changes (Wilcox and Maynard, 1996).

Coastal wetlands occur along the Great Lakes shorelines where erosive forces of ice and wave action are low, allowing the formation of wetland plant communities. They can occupy a wide variety of geomorphological settings that can be grouped into three broad categories based on their physical and hydrologic characteristics: open coast, drowned river mouth/flooded delta, and protected. A continuum exists between these categories, and given the dynamic nature of the shorelines, many coastal wetlands have systematically or episodically migrated along the continuum (Keough et al., 1999).

The Great Lakes coastal wetlands are critical to the Great Lakes ecosystem as a whole. Coastal wetland systems are the most productive aquatic systems in the Great Lakes, and support diverse assemblages of invertebrates, fish, reptile, amphibians, birds and mammals. Whillans (1987) determined that over 90 percent of the roughly 200 fish species in the Great Lakes are directly dependent on coastal wetlands for some part of their life cycle. In terms of waterfowl, 24 species of ducks, four species of geese, and three species of swans are known to use Great Lakes coastal wetlands. These areas are important for many birds other than waterfowl, including shorebirds, wading birds and neotropical migrants (Wilcox and Maynard, 1996).

The Great Lakes coastal systems are important regional and global reservoirs for biological diversity. In a 1994 report on the conservation of biological diversity in the Great Lakes region, The Nature Conservancy identified 131 natural heritage elements (species and natural ecological community types) within the Great Lakes Basin that are critically imperiled, imperiled or rare on a global basis. Of these, 91, or 70 percent of the occurrences, are associated with coastal systems (TNC, 1994).

In addition to providing critical fish and wildlife habitat, Great Lakes coastal wetlands perform a variety of ecological functions important to the healthy functioning of the Great Lakes ecosystem, including flood storage, sediment control, water quality improvement, shoreline erosion protection, food web production and nutrient export.

Habitat-Dependent Activities

Estuarine systems served as the focal point for settlement of the Great Lakes region by Native Americans and Europeans. Historically, due to the ecological functions they provide, estuaries have been preferred as human habitat, and today they are linked inextricably to our economy and our quality of life. The commercial success and the economic importance to the country of cities such as Duluth, Green Bay and Detroit relate directly to the ecological functions that estuaries provide. Today, coastal wetland systems contribute to recreational, commercial, residential, agricultural and industrial activities.

Coastal marshes are great places for non-consumptive recreational uses such as bird watching, nature study, photography and general tourism. Recreational fishing is very important in coastal wetlands. The most sought-after species that use these systems include northern pike, muskellunge, large- and smallmouth bass, yellow perch, white and black crappie, bluegill, channel catfish, black and brown bullhead, carp and bowfin

(Wilcox and Maynard, 1996). In 1983, there was a total of 110,341,000 angler days logged on the Great Lakes (GLNPO, 1988). Waterfowl hunting provides the basis for the recreational hunting industry in coastal wetlands of the Great Lakes. Recreational boating is very popular in the Great Lakes, with Michigan sporting the largest number of registered boaters in the country. Recreational fishing and hunting contribute to local economies through the purchase of food, lodging, equipment and guide services. Although no aggregate numbers of recreation and tourism revenue are available for the Great Lakes Basin as a whole, tourism in Michigan alone is a $10 billion per year industry.

Commercial fisheries associated with coastal wetlands have operated in the Great Lakes for over 125 years. In addition to fish such as northern pike, bass and walleye taken for human consumption, various minnow species are also caught in coastal wetlands as part of an important bait fishery (Wilcox and Maynard, 1996). However, not all commercial use of coastal wetlands has been sustainable. Due to the steady supply of fresh water and access to the Great Lakes for inexpensive shipping of goods and services, many estuarine systems were developed as industrial centers. For example, the Rouge River delta (Detroit, MI) is the home of the Ford Motor Company's Rouge Plant. At one time this marsh habitat was used by Native Americans to harvest wild rice, fish, and fur bearers. Today the entire lower stretch of the Rouge has been channelized and practically all wetlands have been filled (Stapp, personal communication, 2001). Likewise, the river mouths of the Milwaukee (Milwaukee, Wis.), Calumet (Gary, Ind.), Cuyahoga (Cleveland, Ohio) and other rivers have been completely urbanized.

Coastal wetlands in Michigan and Ohio also have suffered severe impacts from drainage for the purpose of agriculture. Because the entire system is freshwater, there are no problems with saltwater intrusion in coastal agricultural fields. Drained wetlands are the most productive agricultural lands in the Great Lakes Basin. Hundreds of square miles of wetlands have been drained around Michigan's Saginaw Bay and in the Maumee Watershed (formerly known as the Black Swamp). Despite the huge loss of wetlands to agriculture, wetlands drained for agricultural purposes that have not been filled or converted to other uses provide the greatest potential for wetland restoration.

Because of the recreational opportunities provided by Great Lakes estuaries, and their scenic beauty, these areas are sought after for resort-residential or second home development. Resorters, or “cottagers,” are seasonal residents who provide a critical boost to local economies but also put stress on coastal resources. Beyond the direct loss of wetland as a result of filling for development, improper stewardship by landowners can result in additional stress on the coastal wetland habitats. Many residents who develop in these areas, for example, attempt to control the dynamic nature of the system by removing vegetation to achieve an unfettered view during periods of low water levels. When the lake levels again rise and their shoreline erodes due to lack of wetland vegetation, they then pressure state and federal agencies to regulate water level fluctuations in the Lakes.

The various habitat-dependent activities affect both the structure and function of the estuarine resources on which they depend. Estuaries have experienced some of the most severe human-caused degradation of any habitat type on earth. Throughout the Great Lakes, estuarine systems have been altered by many of the factors affecting estuaries worldwide. As Great Lakes coastal areas continue to increase in population and popularity, the human impacts on estuarine resources can be expected to increase as well.

Habitat Status and Trends

There are approximately 883 different coastal wetland ecosystems covering approximately 393 square miles on the U.S. side of the Great Lakes. The extent of coastal wetlands (and knowledge about them) varies for each of the Great Lakes. Specific status and trend data is noted in the discussions of each of the Lakes below. Based on a review of available literature and restoration plans, Table 2 offers a general summary of key threats to estuarine habitats in the Great Lakes and connecting channels.

There are numerous natural and human-induced factors that have impacted, and continue to impact, Great Lakes coastal wetlands. Natural stressors include water level fluctuations (both long- and short-term), damage from ice and storms, sediment supply and transport, and biological stressors such as invasive native species or disease (Keough et al., 1999). It is important to note that Great Lakes coastal wetland systems benefit from natural stressors such as water level fluctuations. Sediment supply and transport can be both a positive and a negative for the health of a particular system. The formation of barrier beaches or sand spits can protect macrophytes from waves, but their erosion can expose wetlands to wave action.

Human induced stressors include drainage, filling, dredging, shoreline armoring and modification, changes in water level regime, toxic and nutrient pollution, fragmentation, urban runoff, exotic species invasion, diking of wetlands and global

TABLE 2. KEY THREATS TO ESTUARINE HABITATS IN THE GREAT LAKES AND THEIR ASSOCIATED CONNECTING CHANNELS

General Threats	Specific Threats	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Direct Habitat Alteration	Coastal Development	▲	●	●	●	●
	Dredging	▲	●	●	●	▲
	Filling	▲	▲	▲	▲	▲
	Vegetation Removal	❍	▲	●	▲	❍
	Shoreline Armoring and Modification	❍	▲	●	●	●
	Road Crossings	●	●	●	●	●
Hydrologic Modifications	Dams	❍	▲	▲	❍	❍
	Artificial Changes in Water Level Regime	●	❍	❍	❍	●
	Drainage	❍	●	●	●	●
	Diking	❍	●	▲	●	▲
Nonpoint Source Pollution	Urban Runoff	▲	●	●	●	●
	Agricultural Runoff	❍	▲	●	●	●
	Sewage and Septic	❍	●	●	●	●
Toxic Loading	Point Sources	●	●	●	●	●
	Atmospheric Deposition	●	●	●	●	●
Resource Extraction	Mining	●	▲	▲	❍	❍
	Forestry	●	❍	❍	❍	❍
	Fisheries	❍	❍	▲	▲	▲
Climate Change		●	●	●	●	●
Nuisance, Exotic, and Invasive Species	Purple Loosestrife	❍	●	●	●	●
	Phragmites australis	❍	▲	●	●	●
	Carp	❍	▲	▲	●	●
	Zebra Mussel	▲	▲	●	●	●
	Cattails	❍	▲	●	●	●
	Others (+130 exotics in Great Lakes)	▲	▲	▲	▲	▲
Natural Stressors	Water Level Changes	▲	▲	▲	▲	▲
	Sediment Supply and Transport	❍	❍	❍	❍	❍
	Ice and Storms	▲	❍	❍	❍	❍
	Natural Biological Stressors	❍	❍	❍	❍	❍

KEY: ● High Concern ▲ Medium Concern ❍ Low or No Concern

climate change. This range of stressors has resulted in the loss of coastal wetland habitats and the degradation of the habitat that remains.

It is important to note that these specific threats seldom occur as discrete isolated events. There is interaction between human and natural stressors (e.g., efforts to armor the shoreline during period of high water or to plow shoreline vegetation during low water levels) and substantial interactions among human-induced stressors (e.g., coastal development is typically associated with some sort of hydrologic alteration and always results in non-point source pollution). The cumulative impacts of multiple stressors operating in the same time and place can have synergistic effects well beyond the sum of the individual stressors.

Although no comprehensive studies have been conducted to evaluate the coastal wetland loss rates for the Great Lakes Basin as a whole, studies of specific coastal wetland systems suggest that the losses have been substantial. A study comparing current land use data in Michigan with historical information gleaned from General Land Office (GLO) Surveys conducted in Michigan prior to widespread European settlement found that coastal communities in southeast Michigan (along Saginaw Bay, the Detroit River, and the western shore of Lake Erie) have lost between 90 percent and 97 percent of their original emergent wetlands (many of which were associated with the Great Lakes coast) (Comer, 1996). Similar losses have been reported in southern Ontario. For example, 83 percent of the original 9,367 acres of western Lake Ontario coastal wetlands from Niagara River to Oshawa have been lost, with some sections suffering 100 percent loss due to filling.

The impacts of these losses have not been comprehensively assessed. As noted above, there are numerous species and ecological communities that are globally rare or imperilled in the coastal zone of the Great Lakes. Although the loss of coastal wetland habitats has slowed since the heyday of dredging, draining and filling wetlands, losses in area and wetland function continue to occur.

Regional Planning Efforts

The unique qualities of the Great Lakes and their importance to the U.S. and Canada—both ecologically and economically—have made conservation and restoration of coastal habitats a key objective for bi-national, federal, state and regional planning efforts. Regional efforts of note are highlighted below.

Lakewide Management Plans and Remedial Action Plans

One of the most significant environmental agreements in the history of the Great Lakes took place with the signing of the Great Lakes Water Quality Agreement (GLWQA), between the United States and Canada. The agreement committed the U.S. and Canada (the Parties) to address water quality issues of the Great Lakes in a coordinated, joint fashion. The GLWQA was amended in 1987 and the Parties agreed to develop and implement, in consultation with state and provincial governments, Lakewide Management Plans (LaMPs) for lake basins, and Remedial Action Plans (RAPs) for Areas of Concern (AOCs). LaMPs have been developed for all of the Great Lakes except Lake Huron and include specific objectives for coastal habitat restoration. LaMPs for each lake are briefly described below. Forty-three AOCs were identified: 26 located entirely within the United States; 12 located wholly within Canada; and five shared by both countries. Some RAPs have been completed and are now in the implementation stages, others are still in the development process. Many RAPs contain coastal wetland restoration as a key component.

Lake Huron does not have a Lakewide Management Plan. The Great Lakes Office of the Michigan Department of Environmental Quality, with the U.S. Environmental Protection Agency and Environment Canada as partners, has undertaken the development of the Lake Huron Initiative Action Plan. One purpose of the plan is to determine priority issues and future efforts needed to ensure a sustainable Lake Huron watershed. Immediate future efforts focus on two key issues: critical pollutants and use impairments, and critical habitat and diversity of fish and wildlife populations.

The Nature Conservancy's Ecoregional Planning

In 1996, The Nature Conservancy's (TNC) Great Lakes Program launched a collaborative initiative to develop an ecoregional plan that would identify high priority biodiversity conservation sites in the Great Lakes Region. In 1999, TNC completed a major portion of the plan; this first iteration focussed primarily on selecting sites important for target species and natural communities. Published in 2000, Toward a New Conservation Vision for the Great Lakes Region: A Second Iteration expands the plan to include sites that are important for aquatic systems, reptiles and amphibians. Through the ecoregional planning process, The Nature Conservancy and partners have identified 271 sites that represent the tremendous biological diversity of the Great Lakes region. Of the 271 sites, 166 sites (over 60 percent) are irreplaceable—meaning that these places represent the only opportunity to protect certain species, natural communities, aquatic systems, or assemblages of these targets in the Great Lakes region. Over three-quarters of the sites will need attention within the next 10 years, and more than two-thirds of the sites need more immediate action. Very few of the sites have completed site conservation plans.

Completed plans that contain a restoration component have been included in the discussions for each subregion below.

North American Waterfowl Management Plan

The Upper Mississippi River & Great Lakes Region Joint Venture Implementation Plan establishes the region's goals for the North American Waterfowl Management Plan (NAWMP). It identifies specific habitat objectives for focus areas with the overall objective of increasing populations of waterfowl and other wetland wildlife by protecting, restoring and enhancing wetland and associated upland habitats within the Joint Venture region.

State of the Lakes Ecosystem Conferences

The State of the Lakes Ecosystem Conferences (SOLEC) are hosted every two years by the U.S. Environmental Protection Agency and Environment Canada on behalf of the two Countries in response to the binational Great Lakes Water Quality Agreement. The conferences are intended to provide a forum for exchange of information on the ecological condition of the Great Lakes and surrounding lands. SOLEC conferences are intended to focus on the state of the Great Lakes ecosystem and the major factors impacting it. In addition to reporting on the health of the living system, the conferences report on the underlying conditions. This reflects the increased recognition that the condition of the ecosystem is being determined by three major factors: habitat loss, pollution and exotic species.

State Wetland Management Strategies

Through the US EPA's state wetland development grant program, various states in the Great Lakes Basin have developed state-wide wetland management plans. These plans provide information regarding the status of wetlands in the state, regulatory frameworks, non-regulatory management and protection efforts, and in some cases, recommendations for restoration of the state's wetland resources. State Wetland Management Strategies have been completed for Minnesota, Michigan, Indiana, Illinois, Ohio and New York.

State and Federal Public Land Management

There are numerous state game areas, federal wildlife refuges, Forest Service land, and national parks and lakeshores throughout the Great Lakes Basin. Due to the ecological functions provided by coastal wetlands, many wildlife management areas include substantial coastal wetland systems. Many national wildlife refuges in the coastal areas of the Great Lakes are managed as wilderness. For many state wildlife areas, management plans focus on re-creating or manipulating the system to benefit certain species or hunting opportunities. Wetland restoration is a high priority in many state game areas. By way of an example, selected wildlife management areas are briefly described in the body of this text.

Great Lakes Subregions

In an overview of controlling abiotic factors, Dr. Leah Minc divided the U.S. Great Lakes shoreline into 77 regions characterized by distinctive conditions for coastal wetland development based on differences in climate, bedrock geology, glacial geomorphology, shoreline configuration and soils, as well as land use and disturbance factors (Minc, 1997). In an effort to simplify and to minimize the number of subregions for the purposes of this report, the Great Lakes Region has been divided into five subregions based on geographic boundaries. Each subregion includes the U.S. territory of one of the Great Lakes and the associated downstream connecting channels. The Lake Superior subregion includes Lake Superior and the St. Marys River. The Lake Michigan subregion includes Lake Michigan to the Mackinac Bridge. The Lake Huron subregion encompasses Lake Huron, St. Clair River, Lake St. Clair, and the Detroit River. The Lake Erie subregion includes Lake Erie and the Niagara River. The Lake Ontario subregion encompasses Lake Ontario and the St. Lawrence River downstream to the Quebec border.

LAKE SUPERIOR SUBREGION

Description

The Lake Superior subregion includes Lake Superior and the St. Marys River, which flows from the southeast corner of Lake Superior into Lake Huron. Lake Superior is the largest and coldest of the Great Lakes and is the largest (by surface area) body of freshwater on earth. The lake itself is characterized as oligotrophic, with low levels of nutrients, little plant life, high levels of dissolved oxygen, and a long retention period (191 years). Coastal wetland development is constrained by large areas of bedrock at or near the surface, shallow soils and a northern climate. This northern climate is reflected in the more boreal nature of the wetlands that are typically rich in bog or poor fen species (Minc, 1997). The St. Louis River Estuary and the Bad River and Kakagon Sloughs are significant estuarine systems which comprise a large proportion of the total coastal wetlands in Lake Superior.

The St. Marys River extends 112 kilometers, draining Lake Superior into Lake Huron. The river drops 6.7 meters along its length, mostly at the 1.2 kilometer-long St. Marys Rapids in Sault Ste. Marie. The upper river above the St. Marys Rapids has sandy and rocky shores, with emergent wetlands occurring only in protected areas. The lower river is bordered by exten-

sive emergent marshes in shallow areas of the large lakes, bays and islands (Wilcox and Maynard, 1996).

Habitat Issues

Status and Trends

There are no comprehensive estimates of coastal wetland losses for Lake Superior. In highly developed areas, such as Duluth, Minn. and Superior, Wis., impacts to coastal wetlands have been severe. Because the shoreline is sparsely populated and shoreline development has been minimal, coastal wetlands along Lake Superior are comparatively less affected by human stressors than those of the other Great Lakes. However, due to the relative rarity of wetlands in the Lake Superior system as a result of abiotic factors, those estuarine systems that do exist are particularly important to fish and wildlife populations. (Wilcox and Maynard, 1996). Species of management concern include a variety of freshwater mussels, birds such as the piping plover, peregrine falcon, bald eagle and many rare neotropical passerines, and fish such as the lake sturgeon.

Water level regulation is the most widespread stressor and many other stressors affect wetlands on a site-specific basis. Water level regulation has affected all coastal wetlands in Lake Superior. Water levels on Lake Superior have been regulated for much of the 20th century as a result of the locks at Sault Ste. Marie (Wilcox and Maynard, 1996).

Site-specific stressors include shipping, dredging, filling, harbor and marina development, shoreline development, road construction, nutrient enrichment, logging, and toxic contamination. Watershed runoff of sediments, especially from logging activity, can dramatically increase sediment inputs into tributaries which also can affect coastal wetlands near river mouths, especially in western Lake Superior where watersheds are dominated by fine clay soils. There are three Areas of Concern (AOCs) on the U.S. shoreline of Lake Superior. AOCs are defined as severely degraded areas where beneficial uses are threatened or impaired due to toxic contamination. The entire St. Marys River has been designated an AOC due to elevated contaminants in the water and the sediment.

Threats

Ongoing threats to estuarine systems vary depending on the location of the shoreline. Remote areas are seeing a growth in resort residential development which results in additional pressure on the estuarine resources. In more developed areas, such as Duluth, Minn., and its sister city, Superior, Wis., the threats are many and severe, including dredging and filling, polluted runoff, resuspension of contaminated sediments, hydrological manipulation, shipping and exotic species invasion. At the other end of the lake, the primary threats to the St. Marys River system include resort and residential development and commercial shipping. The passing of large commercial vessels in the narrow reaches of shipping channels causes increased current speed, greater wave action, more erosion, and more turbidity in these coastal wetlands, affecting plant rooting and growth, and associated invertebrates and fauna (Manny et al., 1987 in Wilcox and Maynard, 1996). Vessel speed controls the degree of damage caused by this particular stressor. These threats were addressed in 1998 by a historic multi-party agreement placing permanent speed limits and other conditions on vessel passage (Kavetsky, personal communication).

Restoration Plans

Lake Superior Lakewide Management Plan

The Lake Superior LaMP contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about improvement in the ecosystem. Actions include commitments by the Parties, governments and regulatory programs, as well as suggested voluntary actions that could be taken by nongovernmental partners. Lake Superior habitat objectives include addressing nearshore, shoreline and wetland habitats through identification, protection and restoration of sites for reproduction and rearing of fish, water birds, mammals and other wildlife and plants.

Minnesota's Lake Superior Coastal Program

Coordinated by the Minnesota Department of Natural Resources, this program was designed to meet the requirements for participation in the federal Coastal Zone Management Program. The goal of this program is to preserve, protect, develop and where possible, restore and enhance coastal resources for present and future generations. It was developed to encourage greater cooperation, to encourage simplification of governmental processes, and to provide tools to implement existing policies, authorities and programs within the area defined by the program boundary. It is not another plan to implement, but rather a new tool to implement existing programs in the most efficient manner, and to provide funding for unique or underfunded opportunities.

Chequamegon Bay Watershed Site Conservation Program

A program of The Nature Conservancy, the Chequamegon Bay Watershed Site Conservation Program encompasses two large and numerous small watersheds, and covers three counties in northern Wisconsin. Conservation targets for the program have been identified and include the Kakagon and Bad River Sloughs. Called 'Wisconsin's Everglades,' the Slough system

covers 16,000 acres and is the largest undeveloped system in the upper Great Lakes. Goals for the Slough include: maintaining the integrity and diversity of natural communities; maintaining the natural processes, including lake level fluctuations, flooding, ground water recharge and water quality; controlling aggressive exotic species; and increasing forest cover within the watershed to reduce indirect stresses.

Habitat Plan for Lower St. Louis River

In 1987, the Lower St. Louis River was designated by the International Joint Commission as one of 43 Areas of Concern (AOC). Development of a Remedial Action Plan (RAP) resulted in 43 recommendations. Published in 1995, the RAP contains many habitat-related recommendations. Recommendation 38 calls for the creation of the Habitat Plan for Lower St. Louis River. The goal of the Habitat Plan is to design and implement a coordinated comprehensive plan for the protection and furtherance of biodiversity and ecological diversity within the Area of Concern, without seeking to restore the estuary to its presettlement condition, through the creation, restoration, reclamation, enhancement and management of a desired mix of ecosystems and habitat. The Habitat Plan, managed by the St. Louis River Citizens Action Committee, will focus on the lower 21 miles of the river, a 12,000-acre freshwater estuary from below Fon du Lac, Minn., to its outlet in Lake Superior.

Wisconsin Coastal Management Program

The Wisconsin Coastal Management Program (WCMP) was established in 1978 under the federal Coastal Zone Management Act to protect, restore and enhance Wisconsin's Lake Michigan and Lake Superior coastal resources. The WCMP is a voluntary program that works through a governor-appointed council to award federal funds to local governments and other entities for the implementation of coastal initiatives. The program's goal is to achieve a balance between natural resource protection and coastal communities' need for sustainable economic development.

The WCMP provides grants to encourage the protection and wise use of Wisconsin's coastal resources. One of the four types of matching grants is wetlands protection. A Data Compilation and Assessment of Coastal Wetlands of Wisconsin's Great Lakes was funded in part through this grant program. Goals of this project were to compile existing information on coastal wetlands for Lakes Superior and Michigan in Wisconsin, select ecologically significant primary coastal wetland sites, and identify existing data or inventory gaps. There are 28 primary sites in Wisconsin's Lake Superior coastal region. The report notes that there are relatively few known information gaps in this coastal zone, but that recently some very rare species have been found that need to be inventoried.

Michigan Upper Peninsula Coastal Wetland Project

A Ducks Unlimited proposal to the North American Wetlands Conservation Council, the Michigan Upper Peninsula Coastal Wetland Project is a multi-partner, multi-phase landscape-scale project to protect, restore and manage coastal wetlands and associated uplands within nine focus areas in the Lake Superior and St. Marys watersheds in Michigan. The peninsula has not seen the same great wetland losses as lower Michigan, with the exception of the Rudyard Clay Plain, and for this reason the project focuses on preventing destruction of coastal wetland areas and associated uplands with habitat restoration and enhancement as a secondary objective. Phase I of the project will protect and/or restore 2,826 acres of wetlands and associated uplands through land acquisition in seven focus areas, restoration projects (such as constructing ditch plugs, removing drain tile, and scraping basins in the clay soils) in three focus areas, and enhancement (such as increasing food and habitat resources in a deteriorating impoundment through drawdown and reflooding) in four focus areas. Three additional phases are anticipated.

Munuscong Wildlife Area Management Plan

The Munuscong Wildlife Area is adjacent to Munuscong Lake and the St. Marys River in east-central Chippewa County in Michigan's Upper Peninsula. The management goal for this area is to restore and maintain biotic communities and public use opportunities through practices and improvements that do not disturb existing unique features and which complement, rather than combat, natural processes. Examples of primary objectives are to: “naturalize” a dysfunctional dike and restore the open-system dynamics of the Munuscong Bay coastal marsh while enhancing reproduction opportunities for island-nesting wildlife; maintain upland grassland communities for wildlife species currently using this cover type and create “emergent-marsh” wetlands to enhance grasslands for species dependent on grassland-wetland complexes; and acquire coastal wetlands, grasslands and other tracts within the dedicated wildlife area boundary and manage them as sustainable, naturally functioning systems. Coastal wetland management strategies include work on the dike system, prescribed burns and control measures for purple loosestrife.

Plan Elements

Goals

Habitat goals for the Lake Superior subregion focus on preserving, protecting and restoring coastal wetlands, biodiversity and ecosystem diversity, by restoring natural ecological

processes and addressing the myriad of natural and human induced threats to the system.

Methods

To achieve the subregion's goals, both general methods, such as creating partnerships and building networks, and specific methods were discussed. Examples of specific methods include restoring hardened shorelines and inactive boat slips to natural habitats, eliminating sewer overflows and failing septic systems, toxic remediation, working with local zoning commissions to modify current zoning regulations to ensure appropriate land uses within the watershed, restoring hydrologic regimes, and facilitating consolidation of coastal development including relocating businesses, and using existing facilities versus constructing new ones.

Elements of Success

All of the plans have evolved through, and stress the need for, continued broad participation from federal, state, local and tribal governments, nonprofit organizations and citizens in order to succeed. Most acknowledge the value of supplementing current efforts versus duplicating or recreating existing plans. Site specific measures of success include making measurable progress toward the long-term abatement of critical threats and the sustained maintenance or enhancement of conservation target viability at identified sites.

Information Needs

All plans specify the need to identify highest priority areas for restoration, continue the acquisition of information through research, and secure additional funding sources. The Habitat Plan for the Lower St. Louis River identifies the need to fill data gaps, determines the degree of degradation at specific sites, and determines the need for unified compilation of historical records and resources.

LAKE MICHIGAN SUBREGION

Description

The only Great Lake entirely within the United States, Lake Michigan is the third largest Great Lake, the sixth largest freshwater lake in the world, and has a retention time of 99 years. The Lake Michigan watershed includes part of Indiana, Illinois, Wisconsin and Michigan. The northern watershed is covered with forests, sparsely populated and economically dependent on natural resources. The southern portion is heavily populated with intensive industrial development and rich agriculture areas along the shores (Marine Advisory Service, 1985). Lake Michigan contains 40 percent of the coastal wetland systems along the U.S. Great Lakes shoreline (Lake Michigan Technical Committee, 2000).

Lake Michigan may be the most diverse of any of the Great Lakes. Its shoreline changes from one major landform to another, with each type extending for hundreds of miles. Given the Lake's north-south axis, climate plays a major role in determining the community composition of the various wetland habitats (Minc, 1997). It has lakeplains, high clay bluffs, low erodible bluffs, vast dune fields, rocky cliffs, glacial drift bluffs, sand ridge shores, and clay and pebble embayments flanked by ancient ridges. Lake Michigan's coastal wetlands are equally diverse, including embayed, barrier beach, lagoon, and riverine habitats. Deltaic formation occurs in some Green Bay sites, but shore currents quickly carry away alluvium or detrital accumulations in other areas (Wilcox and Maynard, 1996). Lake Michigan's coastal systems are host to a wide variety of plants, fish and wildlife, including several state and federally listed species such as the Houghton's goldenrod, dwarf lake iris, Pitcher's thistle and the piping plover.

Habitat Issues

Status and Trends

Lake Michigan's water quality and wetlands have been severely degraded. There are ten Areas of Concern in the Lake Michigan Basin, more than any other Great Lake. The Green Bay area has suffered severe losses and degradation of its wetlands as a result of conversion to agriculture, urbanization, and toxic contamination. Along the western shore from Sturgeon Bay, Wis. to Chicago, Ill., urbanization has virtually eliminated former wetlands that once existed near river mouths. South of Chicago and around the bottom of Lake Michigan are many smaller and remnant wetlands and larger interdunal wetlands that survived the heavy industrialization of the area. The drowned river mouths of the Michigan shoreline have had their hydrology altered by road crossings (increasing sediment deposition) and have been affected by ditching, agricultural practices and colonization by invasive plant species. In the less populated, northern extent of Lake Michigan, many of the estuarine systems remain intact.

Threats

In addition to the ongoing problems noted above, current threats to Lake Michigan's coastal wetlands are primarily related to ever-increasing pressure to develop the shoreline. Attracted by the rich recreational opportunities and scenic beauty, the counties at the northern tip of Michigan's lower peninsula have the fastest growing populations in the state. The vibrant tourist and resort economy puts exceptional pres-

sure on the coastal wetland ecosystems. In addition to direct impact on wetlands through dredging and filling for resort residential and marina development, the additional polluted runoff threatens the very resources that tourists and resorters are flocking to the area to enjoy.

Restoration Plans

Lake Michigan Lakewide Management Plan 2000

The Lake Michigan LaMP contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem. Fifteen recommended management actions and activities have been developed and are expected to be completed in the next 14 years. Recommendation Management Action 4, Protect Habitat, addresses wetland restoration with an emphasis on areas connecting to Lake Michigan.

Site Conservation Plan for the Red Banks and Door Peninsula and Islands Landscape

The Northern Door Peninsula and Islands Landscape site begins near the city of Sturgeon Bay, Wis. and covers the northern portion of Door County. This portion of the Door Peninsula extends about 50 miles in a northeast bearing, separating Green Bay from the larger body of Lake Michigan. This plan was developed by The Nature Conservancy through a series of meetings with their conservation partners including the Door County Land Trust, Wisconsin Department of Natural Resources and the U.S. Fish and Wildlife Service. The plan includes two planning units: Red Banks, and the Northern Door Peninsula and Islands Landscapes. The combined acreage of the two sites is 190,000 acres; 2,000 and 188,000 respectively. Each planning unit has site conservation targets with specified goals. Several of the sites, such as Mink River Estuary, North Bay-Mud Lake-Ridges and Kangaroo Lake provide specific strategies to conserve these important coastal wetland systems.

Wisconsin Coastal Management Program

The Wisconsin Coastal Management Program (WCMP) was established in 1978 under the federal Coastal Zone Management Act to protect, restore and enhance Wisconsin's Lake Michigan and Lake Superior coastal resources. The WCMP is a voluntary program that works through a governor-appointed council to award federal funds to local governments and other entities for the implementation of coastal initiatives. The program's goal is to achieve a balance between natural resource protection, and coastal communities' need for sustainable economic development.

The WCMP provides grants to encourage the protection and wise use of Wisconsin's coastal resources. One of the four types of matching grants is wetlands protection. A Data Compilation and Assessment of Coastal Wetlands of Wisconsin's Great Lakes was funded in part through this grant program. Goals of this project were to compile existing information on coastal wetlands for Lakes Superior and Michigan in Wisconsin, select ecologically significant primary coastal wetland sites, and identify existing data or inventory gaps. There are 36 primary coastal wetland sites in Wisconsin's Lake Michigan coastal region. The report identified several major gaps for this region including outdated site descriptions, outdated or missing element occurrence data, inventory of other coastal areas, bird information and dams.

Indiana Dunes: Dunes Creek and the Great Marsh

The Indiana Dunes National Lakeshore and Indiana Dunes State Park protect a large portion of Dunes Creek and what remains of the Great Marsh in northern Indiana. Plans include enhancement of 4,600 acres of currently degraded wetlands through the National Lakeshore's efforts to restore hydrology by plugging man-made ditches and tile drainage and removing fill that obstructs surface water. Specific sites for placement of the ditch plugs and road fill cuts are based on a priority system as determined by need and impact. The Indiana Dunes State Park is developing a comprehensive resource management plan for the park. The plan includes Dunes Creek and Dunes Nature Preserve. In addition, Indiana is developing the Lake Michigan Coastal Program in partnership with the federal Coastal Zone Management Program. The Lake Michigan Coastal Program will work with local governments and organizations to protect and restore important tributaries and natural communities such as Dunes Creek and the Great Marsh.

Lower Green Bay and Fox River Remedial Action Plan (RAP)

The Lower Green Bay and Fox River RAP was developed by the Wisconsin Department of Natural Resources for the Lower Green Bay and Fox River Area of Concern (AOC), consisting of the lower 11.2 kilometers of the Fox River below DePere Dam and 55 square kilometers of southern Green Bay out to Point au Sable and Long Tail Point. The three-phase plan includes a multi-stakeholder partnership with four technical advisory committees and a citizen's advisory committee. Since the RAP was adopted in 1988, 38 of the 120 recommended remedial actions have been implemented. Some of the actions taken to enhance fish, wildlife and habitat are: species reintroduction; creation of walleye spawning habitat; construction of a permanent barrier to sea lamprey at three Fox River sites; and acquisition of 68 hectares of wetlands along the West Shore Wildlife Area.

Muskegon State Game Area Master Plan

The Muskegon State Game Area is located in west central Michigan along a 10-mile stretch of the Muskegon River. It lies mostly in a flood plain, which is forested with lowland hardwood or open marsh, and is largely wetlands wildlife habitat. The major objective of this plan is to maximize management efforts toward waterfowl production, to encourage use of the area by migrant waterfowl, and to provide a quality waterfowl hunting area for sportsmen of Michigan. Wetland habitat protection and restoration will be accomplished primarily through land acquisition and water level control measures.

Plan Elements

Goals

Plans in the Lake Michigan subregion identify both short-term and long-term actions and goals to protect and preserve Lake Michigan coastal regions. The Lake Michigan LaMP identifies 15 management actions for the next 14 years. Examples of these are developing standards or guidelines for ballast water control; completing work on all Clean Legacy Sites by 2005; determining a priority for habitat preservation sites; and filling in data gaps. For the Door Peninsula, The Nature Conservancy sets specific goals for each conservation target, which correlate with strategies for the ecoregional sites. For example, goals for the Hine's emerald dragonfly include maintaining at least two breeding areas within each sub-population on the Door Peninsula, protecting all sub-populations regardless of size, establishing a monitoring plan for each population, and protecting the habitat and processes supporting the species.

Methods

Several methods are suggested for achieving the plans' goals. By 2005, the Lake Michigan LaMP plans to identify and map critical habitats in the watershed for all listed species, which will assist in filling data gaps of coastal habitat. For priority conservation sites in the Door Peninsula, The Nature Conservancy utilizes acquisition and conservation easements to conserve and protect habitat for species such as the Hine's emerald dragonfly.

Elements of Success

As with the other subregions, the ability to build partnerships, link with existing planning efforts, educate and involve the public, and secure continued funding will contribute to the success of the plans. Progress toward reaching tangible improvements (in wetland areas or target species populations) is also a key measure of success.

Information Needs

The Site Conservation Plan for Red Banks and the Door Peninsula provides a detailed matrix of research and inventory needs for conservation targets and assigns a priority to each of the needs. Determining the hydrologic links in the Dolomite-sand-peat landscape, feasibility of exotics control, and relationship of the matrix landscape to the health of the identified targets, are a few examples. The Lake Michigan LaMP identifies the need to fill in gaps of information and verify that available information is still current.

Lake Huron Subregion

Description

The Lake Huron subregion includes Lake Huron, the St. Clair River, Lake St. Clair and the Detroit River. At 59,600 square kilometers, Lake Huron is the second largest of the Great Lakes (after Superior). Lake Huron includes the two largest bays on the Great Lakes, Georgian Bay (in Canada) and Saginaw Bay (Michigan Seagrant, 2000). Lake Huron features a mix of bedrock and glaciated landforms. Rocky shores associated with the Precambrian shield cover the northern and eastern shores and limestone underlies the Drummond Island-Manitoulin Island Group; glacial deposits of till, gravel and sand predominate further south. The diversity of the shoreline and landforms in this subregion is reflected in the wetland habitats, which range from and include sheltered bays and river mouths in Lake Huron to the broad deltaic wetland systems in Lake St. Clair (Minc, 1997). Along the U.S. shoreline, Saginaw Bay has been identified as an Area of Concern (AOC).

The St. Clair River, 64 kilometers long, drains Lake Huron into Lake St. Clair. It is located on the international border between the U.S. and Canada and is a major shipping channel. It forms a large bird-foot delta with many distribution channels and wetlands where it meets Lake St. Clair. The river above the delta is a uniform channel with few bends, no cutoff channels or oxbow lakes, and only two islands. Most of the U.S. shoreline is now artificial and the lack of shoreline complexity, along with the fast current, depth of the river and wave forces generated by large commercial vessels limit wetland development along the banks of the river. The entire St. Clair River has been declared an AOC.

Lake St. Clair is a shallow productive lake located between the St. Clair and Detroit Rivers. Where the St. Clair River meets Lake St. Clair, an expansive bird-foot delta—the largest freshwater delta in the world—has formed with many distribution channels, islands and wetlands. The entire U.S. shoreline of

Lake St. Clair consists of flat, clay lakeplain characterized by slopes of less than one percent with wet loamy clayey soils prevalent (Minc, 1998). At the time of European contact, the Lake St. Clair shoreline was bordered by extensive swamp forests, wet prairies and wet meadows. Shallow water areas contained a nearly continuous band of emergent marsh, while deeper water supported large beds of *Vallisneria americana,* an important food for waterfowl (Minc, 1997). The Clinton River, a tributary to the lake, has been declared an AOC.

The Detroit River connects Lake St. Clair to Lake Erie. It is 51 kilometers long and drops only 0.9 meters along its length. The shoreline stretches 127 kilometers on the U.S. side and several islands occur in the river, with the largest, Grosse Isle, near its mouth. About 95 percent of the total flow in the river enters from Lake St. Clair, and the remainder flows from tributaries and sewer systems, which drain a watershed of 1,844 square kilometers. The natural shoreline consists of clay banks, but 87 percent of the U.S. shoreline is now artificial with revetments and other shoreline hardening structures. Commercial traffic on the river is heavy and Detroit is the busiest port on the Great Lakes. The Detroit River and the Rouge River (a tributary) have both been identified as Areas of Concern (Wilcox and Maynard, 1996).

Habitat Issues

Status and Trends

No comprehensive estimates of coastal wetland loss are available for this subregion. Main causes for wetland losses have been shoreline modification, road construction, filling for urban and resort residential development, and dredging and channelization associated with marina development. The Saginaw Bay area historically contained some of Michigan's most extensive coastal wetlands, but extensive drainage for agriculture and ongoing pumping of diked wetlands for farming purposes have resulted in substantial losses.

Some wetland loss appears to have occurred along the shores of the St. Clair River above the delta, but there is no comprehensive estimate of the extent of loss. Almost all of the U.S. shoreline of the St. Clair River consists of residential, recreational and industrial developments and has been extensively modified. Wetland loss in the river appears to be largely related to extensive bulkheading, shoreline hardening, filling, channelization and dredging along the shores of the river.

Lake St. Clair and the St. Clair Delta have been extensively studied in terms of wetland loss. On the Michigan side of the lake and delta, 4,375 hectares, or 51 percent, of the original wetlands were lost between 1873 and 1968. These losses occurred mostly in the St. Clair Delta, along Anchor Bay and near the mouth of the Clinton River. In 1868 the Clinton River had over 1,295 hectares of wetlands, but by 1973 that amount had been reduced to 221 hectares (Edsall et al., 1988 in Wilcox and Maynard, 1996). Agriculture and urban, residential, and recreational development (e.g., marinas) are the major causes of wetland loss.

From depth surveys of the Detroit River in the 1870s, wetlands and large submergent macrophyte beds were nearly continuous along the shores in historic times. Emergent marshes extended inland from 0.3 meters to 2.0 meters in depth and were sometimes over one kilometer wide, especially near the mouths of tributaries such as the Rouge River. Today, around 87 percent of the U.S. shoreline of the Detroit River has been filled and bulkheaded (Manny and Kenaga, 1991 in Wilcox and Maynard, 1996).

Threats

Threats to the estuarine systems in this subregion become more severe in the southern portions and connecting channels. The northern Lake Huron watershed is still mostly forested, with the main impacts to coastal wetlands resulting from recreational boating and marina development, shoreline development, and mechanized vegetation clearing in the coastal zone. Due to its larger population relative to the northern half of Lake Huron, the stressors on Saginaw Bay's wetlands are even greater. In addition, toxic contamination due to resuspension of contaminated sediment, continued drainage for agricultural purposes, and exotic species such as zebra mussels, carp, and purple loosestrife threaten the integrity of Saginaw Bay wetlands.

On the St. Clair River, continued shoreline hardening, filling, channelization and dredging along the shores fragment the few remaining wetlands along the river, and urban encroachment continues to cause wetland loss and impairment. Ship wakes from large commercial vessels are an important stressor to shoreline habitats, including remnant coastal wetlands, by eroding the shoreline and hampering the establishment of aquatic macrophytes (Wilcox and Maynard, 1996).

Most of the U.S. shoreline of Lake St. Clair and the St. Clair Delta is now developed with marinas, urban or residential developments. Urban, recreational and agricultural encroachment continues to threaten existing wetlands and make restoration very challenging. Another major stress is the diking of wetlands. About half of the wetlands in Lake St. Clair and the St. Clair Delta have been diked. They are managed mainly for waterfowl hunting at the expense of other wetland functions. Diking isolates these wetlands from the upland and lake envi-

ronments, and many wetland functions are impaired. Furthermore, the diversity of wetland habitats are decreased since water level controls are used to maintain particular vegetation and environmental conditions. Other stressors to these wetlands include sediment and nutrient loading from tributaries and invasive species (Wilcox and Maynard, 1996).

Many human stressors continue to impact remaining wetlands on the Detroit River, including erosion from shipping, shoreline modification, dredging and channelization, excess nutrients, contamination of water and sediments with toxic chemicals, agricultural and urban encroachment, and invasive non-indigenous species (Wilcox and Maynard, 1996).

Restoration Plans

Lake Huron Initiative Plan

Initiated by the Department of Environmental Quality's Michigan Office of the Great Lakes with the U.S. Environmental Protection Agency and Environment Canada as partners, The Lake Huron Initiative Action Plan identifies issues of importance to Lake Huron, actions that need to be taken to protect and restore the Lake Huron ecosystem, and development of partnerships to begin undertaking efforts that cannot be accomplished by individual agencies alone. The plan identifies immediate future actions focusing on two key issues: critical pollutants and use impairments, and fish and wildlife populations (habitat and biodiversity).

Measures of Success: Addressing Environmental Impairments in the Saginaw River and Saginaw Bay

The Saginaw Bay Watershed, located along Michigan's east coast on Lake Huron is Michigan's largest watershed and is the largest contiguous freshwater coastal wetland system in the United States. The Measures of Success report was prepared and produced under the guidance of the Partnership for the Saginaw Bay Watershed and represents the collective thoughts of technicians, public officials (federal, state and local), stakeholders and watershed citizens. It provides a brief account of the historical practices responsible for impairments identified in the Saginaw River/Bay Remedial Action Plan, celebrates progress to date in addressing the problems, and proposes measurable goals for the future. In regard to wildlife and habitat, it identifies protecting the ecological integrity of the remaining coastal marsh areas for use by fish and wildlife as the single most important goal in sustaining the diversity and abundance of species. The area below the 585-foot contour within Saginaw Bay and the lower portions of the Bay's tributary streams are identified as the critical coastal marsh areas in need of protection and restoration.

Tobico Marsh Hydrologic Study

Tobico Marsh Hydrologic Study was completed by Resource Management Group, Inc., under contract to Bay County, utilizing funds provided by the Michigan Department of Natural Resources under the Saginaw Bay National Watershed Initiative. The purpose of the study was to determine the nature and extent of historic changes within the Tobico Marsh watershed and determine marsh management options for the future.

Crow Island State Game Area Master Plan

State ownership of the Crow Island State Game Area began in 1953. The Game Area lies within the Saginaw Bay lakeplain, formerly characterized by swamp forest, wet and wet-mesic prairie and emergent marshes. The management plan was developed for the purposes of providing recreation, protecting biodiversity and improving waterfowl production. Examples of habitat management objectives include restoring specified areas (including prior converted wetlands) to functional marshes through controlling water levels, plantings and prescribed burns.

Nayanquing Point Wildlife Area Master Plan

The Nayanquing Point Wildlife Area is located in the east central portion of Michigan's Lower Peninsula, lying along the west side of the Saginaw Bay. The Michigan Department of Natural Resources' overlying intent of management at Nayanquing Point is based on providing suitable habitat to enhance the welfare of the wildlife resource. Improved habitat will serve the needs of local and migrant waterfowl, shorebirds and other wetland wildlife species. Specific management goals and actions are outlined for species, water level control, land acquisition and a barrier beach in the Wildlife Area.

Wigwam Bay Wildlife Area Management Plan

The Wigwam Bay Wildlife Area (WBWA) has an east and west unit, both located in Michigan's Arenac County in the Saginaw Bay area. The Plan's goals and objectives were developed in response to the Michigan Department of Natural Resources' concern for the protection and propagation of wildlife and enhancement of the associated habitat types, as well as the public's desire for the recreational use of the area. The goal is to provide essential habitat for migratory and resident wildlife and recreational opportunities for hunting, trapping and wildlife viewing. Its objectives are: to maintain viable populations of all plants and animal species native to the area with an emphasis on waterfowl and other wetland-related species; to operate and maintain facilities in a cost- effective manner with agricultural practices (intensive management) not promoted; and to manage for specific recreational and species targets. Land acquisition activities are noted as a primary management consideration.

Quanicasse Wildlife Area Management Plan
The Quanicasse Wildlife Area is located along the south shore of Lake Huron's Saginaw Bay. This part of the Saginaw Bay is a valuable marsh and wetland wildlife habitat. The Michigan Department of Natural Resources' primary management goal is to preserve this area for wildlife, thereby preventing future residential or commercial development which would ultimately destroy wildlife values. As such, the main objective relates to land acquisition with management of the area consisting of preserving the marsh in its natural condition.

Saginaw Bay Wetlands Initiative - Phase II
A proposal prepared by Ducks Unlimited and presented to the North American Wetlands Conservation Council, the Saginaw Bay Wetlands Initiative - Phase II continues and broadens a successful multi-year multi-partner effort to protect and restore wetlands and adjacent habitat on public and private lands within Michigan's Saginaw Bay watershed. The focus of Phase II will be protection and restoration of Great Lakes coastal marshes and their associated habitats along Saginaw Bay, expansion of existing state and federal wildlife areas with the restoration of newly acquired lands where possible, and restoration and enhancement of small wetlands and associated uplands important for waterfowl production on private lands throughout the watershed.

St. Clair Flats Wildlife Area Master Plan
The St. Clair Flats Wildlife Area is located in southeastern Michigan on the delta of the St. Clair River as it enters Lake St. Clair and is managed by Michigan's Department of Natural Resources. Some of the primary objectives to preserve or improve wetland type habitat for game and non-game species are: to provide a refuge and food supply for migrating waterfowl, shorebirds and wading birds; and provide more hunting opportunities and improved quality hunting experiences. Several work items are discussed regarding wetland wildlife including vegetative control, water level management, controlled burns and land acquisition.

St. John's Marsh Wildlife Area Habitat Development Plan
The St. John's Marsh Wildlife Area is located in southeastern Michigan, along the northeastern shoreline of Lake St. Clair's Anchor Bay. The marsh makes up the northern portion of the St. Clair Flats Wildlife Area. The Habitat Development Plan's goal is to preserve, protect and enhance existing marsh and upland habitats (3,000 acres), to meet the needs of breeding and migratory waterfowl, along with other wildlife species, while providing practical recreational opportunities for the benefit of all people. To meet the plan's goal, the Michigan Department of Natural Resources established 17 objectives with related action items, such as installation of specified water level control systems.

Plan Elements

Goals
Goals in the Lake Huron subregion focus on restoring and maintaining the chemical, physical and biological integrity of the waters, tributaries, and nearshore terrestrial and aquatic ecosystems. This includes identifying and protecting existing high-quality fish and wildlife habitat sites, as well as the ecosystem processes required to sustain such areas. The Saginaw Bay's Measures of Success plan references the goal of creating 500 acres of wetlands annually for the next 15 years.

Methods
The Lake Huron Initiative discusses many actions needed to protect and restore habitat for the short-term (one to three years) and long-term (longer than three years). Examples include identifying dams and other barriers that are having major ecological impacts; pursuing long-term remediation efforts; supporting development of upstream fishways and downstream passage facilities; and developing lakewide or shared policies on dams, dam removals, maintaining run-of-the-river flows, and dam retirement funding approaches.

Elements of Success
In discussing key concepts for protecting and restoring important habitats, the Lake Huron Plan identifies achieving no net loss of productive capacity of habitats as a sign of success. The Saginaw Bay's Measure's of Success plan references the goal of creating 500 acres of wetlands annually for the next 15 years and states that it is not the physical limitations but rather the economic and social implications of wetland restoration that may make this goal difficult to achieve in the short-term. The social and economic cost of removing land from agricultural production may be too high. For this reason, protecting the ecological integrity of the remaining coastal marsh areas for fish and wildlife is the most important single goal for successfully sustaining the diversity and abundance of species in the Saginaw Bay. As with the other subregions, involving stakeholders and coordinating with other efforts are important to the success of the plans.

Information Needs
There is a need for additional information to better understand the natural processes that support the estuarine systems and the ecology of species of concern in order to ensure that conservation management is most effective. Additional information regarding economic assessment of wetlands and alternative

ecologically sustainable economic activities will also be very important.

Lake Erie Subregion

Description

The Lake Erie subregion includes Lake Erie and the Niagara River. Lake Erie is the smallest of the Great Lakes in water volume, as well as the most shallow, and has a retention/replacement time of 2.7 years. Lake Erie is the most southern of the Great Lakes, and its more moderate climate is marked by the appearance of a distinctively southern floristic component. In addition, the shallow waters of Lake Erie respond rapidly to the annual thermal heating and cooling cycle, creating a distinct growing season environment. However, its east-west orientation parallel to the prevailing storm track makes Lake Erie very susceptible to the passage of storms. Lake Erie is noted for its severe storms, intense wave action and rapid water level changes (Herdendorf and Krieger, 1989 in Minc, 1997).

A large number of coastal wetlands border the low-lying shorelines and estuaries of western Lake Erie in Michigan and Ohio. Along the U.S. shoreline of Lake Erie there are 87 wetlands, encompassing more than 7,937 hectares (Herdendorf et al., 1981b in Minc, 1997). Wetlands of Lake Erie are predominantly lagoon, embayed and drowned river mouth emergent marshes. Many have barrier beaches, but several have been diked for increased shoreline protection and intensive wetland management (Wilcox and Maynard, 1996).

The coastal wetlands of Lake Erie support the largest diversity of plant and wildlife species in the Great Lakes. The moderate climate of Lake Erie and its more southern latitude allow for many species not found along the northern Great Lakes. As a result of this diversity, coastal wetlands of Lake Erie provide habitat for many rare species of plants and wildlife, such as Pennsylvania smartweed, Jefferson's salamander, spotted gar and king rail, and rare wetland communities such as coastal meadow marsh (shoreline fen) occur at several locations (Wilcox and Maynard, 1996).

The Niagara River drains Lake Erie into Lake Ontario. It flows northerly from Lake Erie at Buffalo, N.Y., to Lake Ontario, at Niagara-on-the-Lake. Over the river's 58-kilometer course, it drops almost 100 meters in elevation; 56 meters occurring as the river cascades over the Niagara Escarpment at Niagara Falls. The fast flow of the river has historically precluded wetland development along some reaches of the river (Minc, 1998), and many wetland areas have been degraded or lost. A few wetlands and beds of submergent macrophytes are present in the upper reaches of the river associated with the low sandy shores of islands (Wilcox and Maynard, 1996).

Habitat Issues

Status and Trends

Along the U.S. shore of Lake Erie, large areas of coastal wetlands have been lost over the past 150 years, especially in the western basin of the lake. Prior to 1850, an extensive coastal marsh and swamp system covered an area of approximately 122,000 hectares between Vermilion, Ohio and the mouth of the Detroit River in Michigan, and extending up the valley of the Maumee River. This was part of the Black Swamp, a vast wetland complex 160 kilometers long and 40 kilometers wide (Herdendorf, 1987 in Wilcox and Maynard, 1996). As a result of the development of Toledo at the mouth of the Maumee and the extensive agricultural drainage throughout the watershed, this extensive estuarine system has been nearly completely converted. Today, only about 5,300 hectares of western Lake Erie's coastal marshes remain (Bookhout et al., 1989 in Wilcox and Maynard, 1996). Site specific incremental loss is still occurring from dredging and filling, especially near harbors, marinas and waterfront developments.

There have been no specific studies on wetland loss in the Niagara River, but many wetlands have been reduced in size or lost, and both the Niagara and Buffalo Rivers have been declared AOCs. A large portion of the U.S. shoreline is developed, especially in the Buffalo area where extensive filling has occurred. For instance, the Tifft Street area in Buffalo was formerly the largest emergent marsh on the eastern end of Lake Erie; it was fragmented and largely filled for industrial and railroad development. Similarly, the marsh and submergent macrophyte beds around Rattlesnake Island and in small embayments in the Tonawanda Channel have been filled or dredged for residential or marina developments (New York State Department of Environmental Conservation, 1994 in Wilcox and Maynard, 1996).

Threats

The quality of many of Lake Erie's remaining wetlands has been and continues to be degraded by numerous stressors, especially excessive loadings of sediments and nutrients, contaminants, shoreline hardening, dredging, filling, changes in sediment budgets, exotic species and diking of wetlands.

While excess loadings of phosphorus from point and nonpoint sources have reduced over the last two decades due to control measures, nitrogen loadings from nonpoint sources, mainly

agricultural runoff, have increased in several watersheds (Richards and Baker, 1993 in Wilcox and Maynard, 1996). Many stretches of the U.S. shoreline in western Lake Erie have been modified with dikes, revetments or other shoreline structures for protection of built-up areas and agricultural fields against periodic high water levels and potential for flooding, erosion and property damage. While diking allows for more intensive management of waterfowl and other fauna, it also isolates it from the open waters of the lake, thus impairing many wetland functions.

The extensive use of revetments and other structures has limited the supply of sediments in the littoral drift in western Lake Erie. As a result, the barrier beaches and sand spits that protect wetland plants from wave action are no longer being replenished at a rate equal to or greater than the rate of erosion. As a result, these wetlands are becoming increasingly exposed to wave erosion. Examples occur along Cedar Point in Ohio and Woodtick Peninsula in Michigan. The restoration of Metzger Marsh, a 300-hectare wetland embayment protected from waves by a barrier beach, involved the establishment of a dike to mimic the protective function of the lost barrier beach. Finally, one of the most common stressors in wetlands along the shore of Lake Erie is invasive non-indigenous species including purple loosestrife, zebra mussels and carp.

In addition to many of the stressors discussed above, the Niagara River also is impacted by water withdrawal. More than half of the flow of the Niagara River is diverted for power production, causing dewatering of some marsh areas. This is exacerbated in some areas by road crossings, which restrict wetland hydrology (Wilcox and Maynard, 1996).

Restoration Plans

Lake Erie Lakewide Management Plan

The Lake Erie LaMP is being developed by 20 federal and state agencies along with the Lake Erie Binational Public Forum, a group of Lake Erie citizens interested in improving the lake. The LaMP contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem. Actions include commitments by the Parties, governments and regulatory programs, as well as suggested voluntary actions that could be taken by non-governmental partners.

The Lake Erie LaMP has defined loss of habitat as a major stressor and a beneficial use impairment. Several habitat projects have been completed over the years and a number of others are underway or proposed. Additionally, it proposes a foundation for developing a Lake Erie habitat restoration and protection plan and outlines screening criteria to assist in selecting and highlighting habitat projects that will most strongly support the goals of the Lake Erie LaMP.

Management Plan for Old Woman Creek National Estuarine Research Reserve and State Nature Preserve

The Old Woman Creek National Estuarine Research Reserve was established in Ohio in 1980 and currently encompasses 571 acres of protected estuarine lands and waters. The reserve management plan was approved by NOAA in 2000. Important habitats that may be useful for investigation and as reference sites include upland forests and old-field succession, swamp forests, freshwater marshes, streams and a barrier beach along Lake Erie. Restoration priorities include stream corridor buffer strips and exclusion of carp from the estuary, and serving as a reference site. Current restoration projects include stream bank stabilization.

Erie Marsh Restoration Project

The Erie Marsh Restoration Project is a proposed project of The Nature Conservancy (TNC). Erie Marsh, located 15 miles southwest of Monroe, Mich., is composed of 1,100 acres of diked marshland and 1,068 acres of open water. The area sited for restoration, Widgeon Hole, is 83 acres near the center of the marsh. The area will be managed for *Phragmites australis* control. Necessary steps include draining the Widgeon Hole, prescribed burning to remove biomass, and herbiciding the *Phragmites* followed by flooding. The site will be managed to promote native plant species and attract waterfowl by recreating marsh habitat. The restoration will serve as a pilot project to determine whether Great Lakes marsh habitat can be restored within a system that is controlled by dikes. It will be monitored by TNC to determine the success of invasive species removal, viability of native seed bank versus manual seeding of the site, and locations and abundance of the state-threatened Eastern fox snake.

Lake St. Clair/Western Lake Erie Watershed Project

A Ducks Unlimited proposal to the North American Wetlands Conservation Council, the Lake St. Clair/Western Lake Erie Watershed Project will continue and broaden existing efforts to protect and restore wetlands and adjacent habitat on public and private lands within the Lake St. Clair and western Lake Erie watershed including the Detroit River. The focus of the project will be on protection and restoration of Great Lakes coastal marshes and their associated habitats, expansion of existing state and federal wildlife areas, and restoration and enhancement of small wetlands and associated uplands important for waterfowl production on private lands throughout the watershed.

Erie State Game Area Master Plan

Michigan Department of Natural Resources' Erie State Game Area is located in the extreme southeastern corner of Michigan's Monroe County on Maumee Bay, an estuary of Lake Erie. The primary objectives of the master plan are to preserve and maintain wetland habitat for game and non-game species; to restore and create up to 2,000 acres of marsh; to provide increased nesting cover, food and resting area for migrating waterfowl; to provide increased recreational hunting opportunities near a heavily populated area in Michigan, and to provide for public uses such as wildlife viewing, photography and trapping. The plan proposes a barrier island be constructed to prevent further erosion and installation of water control structures and pumps.

Lake Erie Marshes Focus Plan

A flagship project under the North American Waterfowl Management Plan's Lower Great Lakes/St. Lawrence Basin Joint Venture, the Lake Erie Marshes Focus Plan encompasses the Ohio counties of Lucas, Wood, Ottawa, Sandusky and Erie. Managed by the Ohio Department of Natural Resources' Division of Wildlife in cooperation with the U.S. Fish and Wildlife Service, the project's goal is to provide at least 17,540 additional acres of high quality wetland habitat in the Lake Erie Marsh (Great Black Swamp) region. To meet this goal, two major habitat objectives have been identified: 1) wetland habitat protection; and 2) wetland habitat restoration and enhancement. Wetland habitat protection is defined in a broad sense and includes any legal arrangement that results in habitat protection and/or requires an expenditure of time or money to bring about. The protection goal is 10,764 acres, with 7,639 in fee title acquisition. The wetland habitat restoration and enhancement goal is 6,776 acres on federal, state and private lands.

Pointe Mouillee State Game Area Master Plan

The Pointe Mouillee State Game Area is located on the Lake Erie shoreline in the southeast corner of Michigan between Detroit and Toledo. Phase 1 of the project called for restoration of 1,900 acres of marsh through construction of dikes and installation of water control structures, duplicating the former creeks and channels that existed in the marsh in the early 1950s. Phase II of the plan involves basic marsh management (no construction) such as de-watering the lake bottom between the barrier island and dikes by pumping and establishing emergent plant communities on the exposed mud flats. The restored marsh will be maintained in as natural a condition as possible with free flow of waters from Lake Erie. Changes in this basic plan will take place only where changes in Lake Erie water levels or other factors cause deterioration in the optimum growth of emergent and submergent aquatic plant communities. Management practices including de-watering (drawdown), or flooding by pumping or gravity flow, may be necessary to assist nature in maintaining the desired balance.

Lake Erie Protection and Restoration Plan

The Lake Erie Protection and Restoration Plan was produced by the Ohio Lake Erie Commission (Commission), a state agency comprised of the directors of the Ohio Department of Natural Resources, Ohio Environmental Protection Agency, and the Departments of Agriculture, Development, Health, and Transportation. In 1998, the Commission released the Lake Erie Quality Index, which evaluated 10 separate indicators of Lake Erie quality, including habitat. The evaluation of indicators showed positive trends, as well as areas with little progress toward mitigating impacts of past practices. The Quality Index set environmental, recreational and economic goals and objectives. The plan identifies 84 specific recommendations to accomplish these goals and objectives and includes protection and restoration of valuable coastal properties.

Strawberry Island/Motor Island Shallows Restoration Plan

The Strawberry Island/Motor Island Shallows is located near the southern tip of Grand Island where it has been endangered due to gravel dredging and the erosive forces of the Niagara River's strong currents and ice flows. Strawberry Island, the upstream sentinel of the complex, once totaled more than 200 acres of wetland habitat and forest but now consists of only five acres. The New York State Department of State officially designated this area a “significant coastal fish and wildlife habitat.” A $1 million restoration project is underway to protect shorelines and restore the endangered aquatic habitat. The project is jointly sponsored by a variety of federal, state and local government and natural resource management organizations, and it is funded by the New York State Clean Water/Clean Air Bond Act and State Department of Transportation funds.

Plan Elements

Goals

Goals in lakewide plans that benefit wetlands are general, including coordination of management efforts, protection of existing estuarine systems, reducing contaminant loading, managing phosphorus, managing changes in land use, controlling exploitation by sport and commercial harvest, and creating and restoring natural landscapes.

Methods

Methods include reducing toxic and sediment loads, perma-

nent land protection (through purchase or easement), expanding research, coordinating management among various agencies, controlling exotic species through herbicide use and prescribed burning, managing recreation, re-establishing native vegetation, restoring natural littoral processes, restoring natural lake level fluctuations, and expanding education and outreach.

Elements of Success

Key elements of success include public education and involvement, cooperation and coordination of a wide range of stakeholders, and achieving progress on measurable indicators of success related to the particular estuarine system to be restored (e.g., increase in target species population and expansion of vegetated areas).

Information Needs

The plans acknowledge the need for additional information to apply sufficient understanding of the natural processes that support the estuarine systems and the ecology of species of concern in order to ensure that conservation management is most effective. The response of target species to the restoration activities will be monitored, and this information will be used to modify future restoration efforts.

LAKE ONTARIO SUBREGION

Description

The Lake Ontario subregion includes Lake Ontario and the St. Lawrence River to the Quebec border. Lake Ontario is the smallest of the Great Lakes in surface area (18,960 square kilometers) but is relatively deep, with an average depth second only to Lake Superior. Water levels in the lake are controlled by dams and locks in the St. Lawrence River, and natural lake level fluctuations have been dampened significantly (Minc, 1997).

Along the U.S. side, Lake Ontario is bordered by low glacial till bluffs. As a result, most of Lake Ontario's shoreline (85 percent) is characterized by regular shorelines sloping rapidly into deep waters, which preclude extensive wetland development (Minc, 1997). In the U.S. portion of Lake Ontario, 168 wetlands covering 5,529 hectares are present (Herdendorf et al., 1981a in Wilcox and Maynard, 1996). Wetlands are most abundant along the eastern end of the lake owing to sand accumulation in the form of barrier beaches. Dominant wetland types include barrier-beach lagoons and partially barred lacustrine estuaries (Minc, 1997). In addition to these emergent and submergent marsh communities, there also are some swamps and a few rare shoreline fen communities. These coastal wetland systems provide important fish and wildlife habitat for the entire lake ecosystem.

The St. Lawrence River is the sole outlet of the entire Great Lakes. From its origin near Wolf Island, it flows northeast between New York and Ontario for 182 kilometers before entering the Province of Quebec. Water level and flows for this section of the St. Lawrence River have been regulated since the construction of the St. Lawrence Seaway in 1959. Since then, dams and water control structures have greatly changed the character of the river and its wetlands. The Thousand Islands section lies in the uppermost reach of the river. It has a rocky shoreline and many islands, bays and shoals with extensive wetlands. Downstream from the Thousand Islands, the St. Lawrence River goes from a single deep and wide channel with fast currents and a relatively uniform shoreline to a lacustrine-like system (created as a result of dam construction for the Seaway) with extensive wetlands located at creek mouths, in embayments and surrounding islands (Grant, 1995 in Wilcox and Maynard, 1996).

Habitat Issues

Status and Trends

Along the entire U.S. shore, Lake Ontario wetland losses have been estimated to be near 60 percent (Busch et al., 1993 in Wilcox and Maynard, 1996). Most of the losses are associated with the heavily populated areas surrounding Oswego and Rochester, but losses have also occurred as a result of resort residential and marina development, especially around large barrier beaches. Three Areas of Concern (AOC) are located in the Lake Ontario subregion including Eighteen Mile Creek, Rochester and Oswego in New York.

Water levels in Lake Ontario and the St. Lawrence River have been regulated in the lake since construction of the St. Lawrence Seaway in 1959. Prior to regulation, the range of water level fluctuations during the 20th century was about two meters. Following regulation, this range was reduced slightly between 1960 and 1976 and was reduced to about 0.9 meters after 1976. The lack of alternating flooded and de-watered conditions at the upper and lower edges of the wetlands decreased wetland area and the diversity of plant and wildlife communities (Busch et al., 1990; Wilcox et al., 1993 in Wilcox and Whillans, 1999). Upland species became more prevalent along the upper edges of the wetlands, emergent communities declined in area, aquatic macrophyte beds increased, and invasive plants began to dominate wetland communities. Extensive stands of cattail are now established in these wetlands, and many areas are dominated by purple loosestrife, reed canary grass and various shrubs.

The St. Lawrence River has experienced a wide variety of environmental disturbances since the channel was modified for shipping purposes. The largest disturbance was associated with the construction and operation of the St. Lawrence Seaway. Impacts include inundation from dams, regulation and stabilization of water flows, and direct impacts from dredging and filling. The St. Lawrence River is a focal point for a strong resort residential and tourist economy. Like other parts of the Great Lakes system, this has brought with it shoreline development, road construction, and dredging and filling associated with marina development and operation.

Threats

The remaining wetlands in Lake Ontario and the St. Lawrence River are affected by several human stressors, including manipulation of lake levels, toxic contaminants, high sediment loads, excess turbidity related to urban and agricultural runoff, excess nutrients, shoreline modification, dikes and revetments. Small-scale wetland loss continues as a result of shoreline development, especially around large barrier beaches and near larger cities, and dredging and filling associated with harbors, marinas and waterfront developments.

Restoration Plans

Lake Ontario Lakewide Management Plan 2000

The Lake Ontario LaMP contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem.

Eastern Lake Ontario Megasite Site Conservation Plan

The Nature Conservancy (TNC) has prepared a Site Conservation Plan for the Eastern Lake Ontario Dune and Wetland Complex, which includes a core of 16,000 acres, along 17 miles of Lake Ontario shoreline in Oswego and Jefferson Counties, New York. The plan identifies long-term conservation goals and describes a proposed five-prong approach to conservation and restoration of ecoregional targets. Targets include Great Lakes dunes and the coastal marsh ecosystems, and species such as the Champlain beachgrass, bog buckmouth and bog turtle. The plan also identifies the following declining and vulnerable bird targets: black tern, American bittern, sedge wren, and migratory stopover habitat for landbirds, shorebirds, raptors and waterbirds.

Eastern Great Lakes Lowlands Program Area Strategic Plan

Ducks Unlimited's Eastern Great Lakes Lowlands Program Area Strategic Plan covers 32,500 miles of low-lying lake plain habitats in New York, Pennsylvania and Ohio. The Plan establishes focus areas, with some addressing coastal wetlands such as Pennsylvania's St. Lawrence Valley and Northwest Counties focus areas. The plan sets five-year goals which include protecting 5,000 acres of wetland and associated upland habitat through acquisition and conservation easements, restoring and enhancing 9,000 acres of wetland habitat, and reducing sediment, nutrient and toxic loading into Lakes Erie and Ontario.

French Creek Wildlife Management Project

The French Creek Wildlife Management Area is located in the town of Clayton in Jefferson County, 20 miles north of Watertown, N.Y. It consists of 2,265 acres of small streams, cattail marshes, open meadows and upland hardwood forest that provide habitat for endangered, threatened and species of concern including the American bald eagle, osprey, black tern, Blandings turtle, pugnose and blackshin shiners, and a variety of migratory waterfowl and fur-bearing species. In order to mitigate the negative effects of the St. Lawrence Seaway System's hydrology, the restoration project involves design and construction of an earthen dam and innovative gate water level control system. The system provides the flexibility for current and future biodiversity management needs with the ability to adjust water levels while allowing fish passage.

Plan Elements

Goals

Goals in these plans range from the very broad (e.g., society acts with responsible stewardship of the Lake Ontario basin) to the more specific. Specific goals include long-term maintenance of functioning dune and bluff barrier systems, managing recreation on undeveloped portions of the barrier dune and beach systems, and maintaining a mosaic of healthy wetlands to support populations of the vast assemblage of rare and common plants and animals.

Methods

Methods include reducing toxic and sediment loads, protecting land through conservation easement or purchase; expanding research and the application of scientific information; coordinating management among various agencies; controlling exotic species; managing recreation; re-establishing native vegetation; restoring natural lake level fluctuations; and expanding education and outreach.

Elements of Success

Key elements of success include public education and involvement, cooperation and coordination of a wide range of stakeholders, and achieving progress on measurable indicators of success.

Information Needs

The plans acknowledge the need for additional information to apply sufficient understanding of the natural processes that support the estuarine systems and the ecology of species of concern in order to ensure that conservation management is most effective.

REFERENCES

Chow-Fraser, P., and D. Albert. 1999. Biodiversity Investment Areas Coastal Wetland Ecosystems: Version 3: State of the Lakes Ecosystem Conference 1998.

Comer, P. J. 1996. Wetland Trends in Michigan Since 1800: a preliminary assessment.

Ducks Unlimited. 1999. Michigan Upper Peninsula Coastal Wetland Project.

Ducks Unlimited. 2000. *Eastern Great Lakes Lowlands Program Area Strategic Plan.*

Ducks Unlimited. 2000. *Saginaw Bay Wetland Initiative - Phase II.*

Ducks Unlimited. 2001. Lake St. Clair/Western Lake Erie Watershed Project.

Environmental Protection Agency. 1980. Great Lakes America.

Great Lakes National Program Office (GLNPO) of Environmental Protection Agency. 1988. The Great Lakes: An Environmental Atlas and Resource Book.

Herdendorf, C.E. and S.M. Hartley, and M.D. Barnes, eds. 1981. Fish and Wildlife Resources of the Great Lakes Coastal Wetlands within the United States. Volume one: Overview. U.S. Fish and Wildlife Service. Washington, D.C. FWS/OBS-81/o2-v1. 469 pages.

Indiana Department of Natural Resources. 1996. *Indiana Wetlands Conservation Plan.*

Indiana Department of Natural Resources, Indiana Lake Michigan Coastal Program. 2001. Indiana Dunes: Dunes Creek and the Great Marsh.

Kavetsky, Robert. U.S. Fish and Wildlife Service, Lansing, Michigan. Personal Communications.

Keough, J.R., T.A. Thompson, G.R. Guntenspergen, and D. Wilcox. 1999. Hydrogeomorphic Factors and Ecosystem Responses in Coastal Wetlands of the Great Lakes. Wetlands, Vol. 9, No. 4., Journal of the Society of Wetland Scientists.

Lake Erie Lakewide Management Plan Work Group. 2000. *Lake Erie Lakewide Management Plan.*

Lake Michigan Technical Committee. 2000. *Lake Michigan Lakewide Management Plan.*

Lake Superior Binational Program. 2000. *Lake Superior Lakewide Management Plan.*

Marine Advisory Service. 1985. Lake Michigan. Extension Bulletin E-1867.

Merryfield, N., E. Epstein, A. Galvin, E. Judziewicz, W. Smith. 2000. A Data Compilation and Assessment of Coastal Wetlands of Wisconsin's Great Lakes.

Michigan Department of Environmental Quality, Office of the Great Lakes. March 2000. *Lake Huron Initiative Action Plan.*

Michigan Department of Natural Resources-Wildlife Division. 1977. *Erie State Game Area Master Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division. 1977. M*uskegon State Game Area Master Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division. 1977. N*ayanquing Point Wildlife Area Master Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division. 1977. *Quanicassee Wildlife Area Master Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division. 1977. *St. Clair Flats Wildlife Area Master Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division. 1977. *Wildfowl Bay State Game Area 10-Year Management Plan 1977-1987.*

Michigan Department of Natural Resources-Wildlife Division.

1991. *St. John's Marsh Wildlife Area Habitat Development Plan 1991-2000.*

Michigan Department of Natural Resources-Wildlife Division. 1992. *Tobico Marsh State Game Area Master Plan.*

Michigan Department of Natural Resources-Wildlife Division. 1994. *Wigwam Bay Wildlife Area Management Plan.*

Michigan Department of Natural Resources-Wildlife Division. 1995. *Munuscong Wildlife Area Management Plan: An Ecosystem Conservation and User Accommodation Approach.*

Michigan Department of Natural Resources-Wildlife Division. 1996. *Crow Island State Game Area 5-Year Master Plan.*

Michigan Department of Natural Resources-Wildlife Division. *Point Mouillee State Game Area Master Plan.*

Michigan Sea Grant, and Michigan State Extension. 2000. The Great Lakes Basin.

Michigan Wetland Advisory Committee. 1997. Michigan's Wetland Conservation Strategy.

Minc, L.D. 1997. Vegetative Response in Michigan's Coastal Wetlands to Great Lakes Water-Level Fluctuations: Michigan Natural Features Inventory.

Minc, L.D. 1998. Great Lakes Coastal Wetlands: An Overview of Controlling Abiotic Factors, Regional Distribution, and Species Composition: Michigan Natural Features Inventory.

Minc, L.D., and D.A. Albert. 1998. Great Lakes Coastal Wetlands: Abiotic and Floristic Characterization: Michigan Natural Features Inventory.

Minnesota Department of Agriculture, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Board of Water & Soil Resources, and Minnesota Department of Transportation. 1997. *Minnesota Wetlands Conservation Plan.*

Minnesota Department of Natural Resources. 1999. Minnesota's Lake Superior Coastal Program.

Minnesota Pollution Control Agency, Wisconsin Department of Natural Resources. April 1995. *The St. Louis River System Remedial Action Plan Progress Report.*

Ohio Department of Natural Resources-Division of Wildlife, U.S. Fish and Wildlife Service. *The Lake Erie Marshes Focus Area Plan.*

Ohio Lake Erie Commission. 2000. *Lake Erie Protection and Restoration Plan.*

Ohio Wetlands Task Force. 1994. Report & Recommendations.

Old Woman Creek National Estuarine Research Reserve. 1999. *Management Plan for Old Woman Creek National Estuarine Research Reserve and State Nature Preserve.*

Public Sector Consultants Inc. 2000. Measures of Success: Addressing Environmental Impairments in the Saginaw River and Saginaw Bay.

Resource Management Group. 1995. Tobico Marsh Hydrologic Study.

Stapp, William B. University of Michigan, Ann Arbor, Michigan. Personal Communications.

St. Louis River Citizens Action Committee. 2001. *Draft Habitat Plan for the Lower St. Louis River.*

The Nature Conservancy (TNC). 1994. The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities.

The Nature Conservancy (TNC). 2000. *Chequamegon Bay Watershed Site Conservation Plan.*

The Nature Conservancy (TNC). 2000. *Eastern Lake Ontario Megasite Site Conservation Plan.*

The Nature Conservancy (TNC). 2000. *Site Conservation Plan for Red Banks and the Door Peninsula and Islands Landscape Sites.*

The Nature Conservancy (TNC). 2000. Toward a New Conservation Vision for the Great Lakes Region: A Second Iteration.

The Nature Conservancy (TNC). 2001. Erie Marsh Restoration.

Upper Mississippi River & Great Lakes Region Joint Venture. 1998. *Implementation Plan.*

U.S. Environmental Protection Agency, Environment Canada, New York State Department of Environmental Conservation, and the Ontario Ministry of the Environment. 1998. *Lakewide Management Plan for Lake Ontario.*

U.S. Fish and Wildlife Service Great Lakes Coastal Program. 2001. 2001 Planned Activities.

Whillans, T.H. 1987. Wetlands and aquatic resources. In: M.C. Healey and R.R. Wallace, eds. Canadian Aquatic Resources, Canadian Bulletin of Fisheries and Aquatic Sciences 215, 321-356.

Wilcox, D., and L. Maynard. 1996. Coastal Wetlands: State of the Lakes Ecosystem Conference 1996.

Wilcox, D., and T. Whillans. 1999. Techniques for Restoration of Disturbed Coastal Wetlands of the Great Lakes. Wetlands, Vol. 9, No. 4., Journal of the Society of Wetland Scientists.